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Nanomanufacturing - Key control characteristics -
Part 6-24: Graphene-related products - Number of layers of graphene: optical contrast

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CONTENTS

FOREWORD 3
INTRODUCTION 5
1 Scope 6
2 Normative references 6
3 Terms and definitions 6
4 General 7
4.1 Measurement principle 7
4.2 Description of measurement equipment 8
4.3 Sample preparation 8
5 Measurement procedure 9
5.1 Establish the correlation between G-channel contrast value C_G and number of layers 9
5.2 White balance calibration 9
5.3 Set up the digital camera 9
5.4 Capture the optical image 9
5.5 Obtain G-channel contrast images 9
5.6 Determine the G-channel contrast values of the samples with known number of layers 9
6 Data analysis or interpretation of results 10
7 Results to be reported 10
Annex A (normative) Optical contrast values of samples with known number of layers 12
Annex B (normative) Acquire the number of layer distribution of monolayer CVD graphene 14
Annex C (normative) Acquire the number of layer distribution of CVD graphene with multilayer domains 17
Annex D (informative) Transfer of CVD grown graphene films 20
Bibliography 21

Figure 1 – Schematics of the optical contrast method 8
Figure A.1 – Optical image, Raman spectra and Raman G-band mapping of the mechanically exfoliated graphene flake 12
Figure A.2 – G-channel image of the exfoliated graphene flake extracted from the optical image 13
Figure A.3 – 3D G-channel contrast image of the exfoliated graphene flake with light illumination corrections 13
Figure B.1 – Optical image of the CVD monolayer graphene 14
Figure B.2 – G-channel image of the CVD monolayer graphene extracted from the optical image 14
Figure B.3 – 3D G-channel contrast image of the CVD monolayer graphene with light illumination corrections 15
Figure B.4 – Histogram of the G-channel contrast values across the optical image 15
Figure B.5 – Curve fitting of the G-channel contrast histogram 15
Figure C.1 – Optical image of the CVD graphene films 17
Figure C.2 – G-channel image of the CVD graphene films extracted from the optical image 17

Figure C.3 – 3D G-channel contrast image of the CVD graphene films with light illumination corrections 18
Figure C.4 – Histogram of the G-channel contrast values across the image 18
Figure C.5 – Curve fitting of the G-channel optical contrast histogram 18

Table 1 – The relationship between G-channel contrast values C_G and number of layers 9
Table 2 – The peak position of G-channel contrast value and area ratio 10
Table A.1 – Relationship between reference C_G and number of layers 13
Table B.1 – The peak position of G-channel contrast value and area ratio 16
Table C.1 – The peak position of G-channel contrast value and layer ratio 19

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Nanomanufacturing - Key control characteristics - Part 6-24: Graphene-related products - Number of layers of graphene: optical contrast

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Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available

at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts of the IEC 62607 series, published under the general title *Nanomanufacturing - Key control characteristics*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

– reconfirmed,

– withdrawn, or

– revised.

INTRODUCTION

Graphene, as a pioneer of 2D materials, plays a critical role in many state-of-the-art applications, extensively involving electronics, optoelectronics, sensors, and energy storage. [1][1] Graphene has many desirable properties, e.g. high carrier mobility, broadband optical absorption, biocompatibility and excellent stability and hence has good prospects not only for basic research but also for various industrial applications. Large-area graphene film fabricated by chemical vapour deposition (CVD) method is one of the most promising candidates for commercialization. However, large-area CVD graphene films typically contain multilayer domains that occupy varying proportions of the surface area, which can significantly affect their electrical, mechanical and optical properties. Therefore, it is crucial to quantitatively assess number of layer distribution (i.e. the area proportions for various layer domains) in CVD graphene films for both research and application development.

There are many approaches for measuring number of layers of graphene films, such as transmission electron microscopy (TEM), Raman spectroscopy, optical microscopy, and atomic force microscopy (AFM). However, how to measure number of layer distribution is not specified yet. This will affect application development and commercialization of large-area CVD graphene film.

This document specifies a simple, high-throughput, and non-destructive approach to measure number of layer distribution of large-area CVD graphene film by optical contrast method. The basic principle and experimental approach of the optical contrast method are presented to identify number of layer distribution. This method relies on the statistical analysis of the optical contrast values of the pixels that make up the sample's optical images, and it is significantly more efficient than TEM, AFM and Raman spectroscopy characterization method. With light illumination corrections, the coverage ratio of monolayer and multilayer domains in large-scale CVD graphene can be obtained accurately.

[1] Numbers in square brackets refer to the Bibliography.

1 Scope

This part of IEC 62607 establishes a standardized method to determine the key control characteristic (KCC)

– number of layer distribution

for CVD graphene film by

– optical contrast measurement

The number of layers and number of layer distribution of CVD graphene film is derived by G-channel contrast values.

This method is applicable for clean CVD graphene film without twisted multilayer structures on a SiO_2/Si substrate.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC TS 62607-6-11:2022, *Nanomanufacturing - Key control characteristics - Part 6-11: Graphene - Defect density: Raman spectroscopy*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

– IEC Electropedia: available at https://www.electropedia.org/

– ISO Online browsing platform: available at https://www.iso.org/obp

3.1
optical contrast value
C
normalized difference in reflected light intensity between the blank substrate and the sample on the substrate

$$C = \frac{I_{\text{substrate}} - I_{\text{sample}}}{I_{\text{substrate}}} \quad (1)$$

where

$I_{\text{substrate}}$ is the reflected light intensity of the blank substrate;

I_{sample} is the reflected light intensity of the sample on the substrate.

3.2
G-channel value
value extracted from green channel (G-channel) at each pixel in the optical image

Note 1 to entry: The G-channel value is in the range 0 to 255.